eNAV14- 17.1.3.4

**Annex 2**

**Working Document Toward**

**Preliminary Draft New Recommendation ITU-R M.[VDES][[1]](#footnote-1)\***

Technical characteristics for a VHF Data Exchange System (VDES) in the VHF maritime mobile band

Scope

This Recommendation provides the technical characteristics of a VHF data exchange system (VDES) which integrates the functions of VHF Data Exchange (VDE), Application Specific Messages (ASM) and the automatic identification system (AIS) in the VHF maritime mobile band (156.025-162.025 MHz).

The ITU Radiocommunication Assembly,

considering

a) that the International Maritime Organization (IMO) has a continuing requirement for a universal shipborne automatic identification system (AIS);

b) that the use of a universal shipborne AIS allows efficient exchange of navigational data between ships and between ships and shore stations, thereby improving safety of navigation;

c) that a system should be designed using self-organized time division multiple access (SOTDMA) along with other appropriate access schemes and efficient data transmission methods, and sufficient spectrum should be designated, to accommodate all users and meet the likely future requirements for efficient use of the spectrum;

d) that while AIS is used primarily for surveillance and safety of navigation purposes in ship to ship use, ship reporting and vessel traffic services (VTS) applications, a growing need for other maritime safety related communications has developed;

e) that the VHF data exchange system shall give priority to AIS, and also accommodate future expansion in the number of users and diversification of data communications applications, including vessels which are not subject to IMO AIS carriage requirements, aids to navigation and search and rescue;

f) that the VHF data exchange system has data communications capacity and technical characteristics that support the harmonized collection, integration, exchange, presentation and analysis of marine information onboard and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment,”

recognizing

that the implementation of VDES must ensure that the functions of DSC, AIS and voice distress, safety and calling communication (Channel 16), are not impaired;

recommends

**1** that VDES should be designed in accordance with the operational characteristics given in Annex 1 and the technical characteristics given in the Annexes XX (to be draft);

**2** that applications of the VDES which make use of application specific messages (ASM) designed for AIS, as defined in Recommendation ITU-R M 1371 should also take into account the international application identifier branch, as specified in IMO SN Circ. 289, maintained and published by IMO;

**3** that the design and installation of VDES should also consider relevant technical requirements, recommendations and guidelines published by IMO, IEC and IALA.

Annex 1  
  
Operational characteristics of a VHF Data Exchange System (VDES) in the VHF maritime mobile band

# 1 General

**1.1** The system should give its highest priority to AIS position reporting and safety related information.

**1.2** The system installation should be capable of receiving and processing all specified digital messages and interrogating calls specified by this Recommendation.

**1.3** The system should be capable of transmitting additional safety information on request.

**1.4** The system installation should be able to operate continuously while under way or at anchor.

**1.5** The system should use TDMA techniques, access schemes and data transmissioin methods in a synchronized manner as specified in the Annexes.

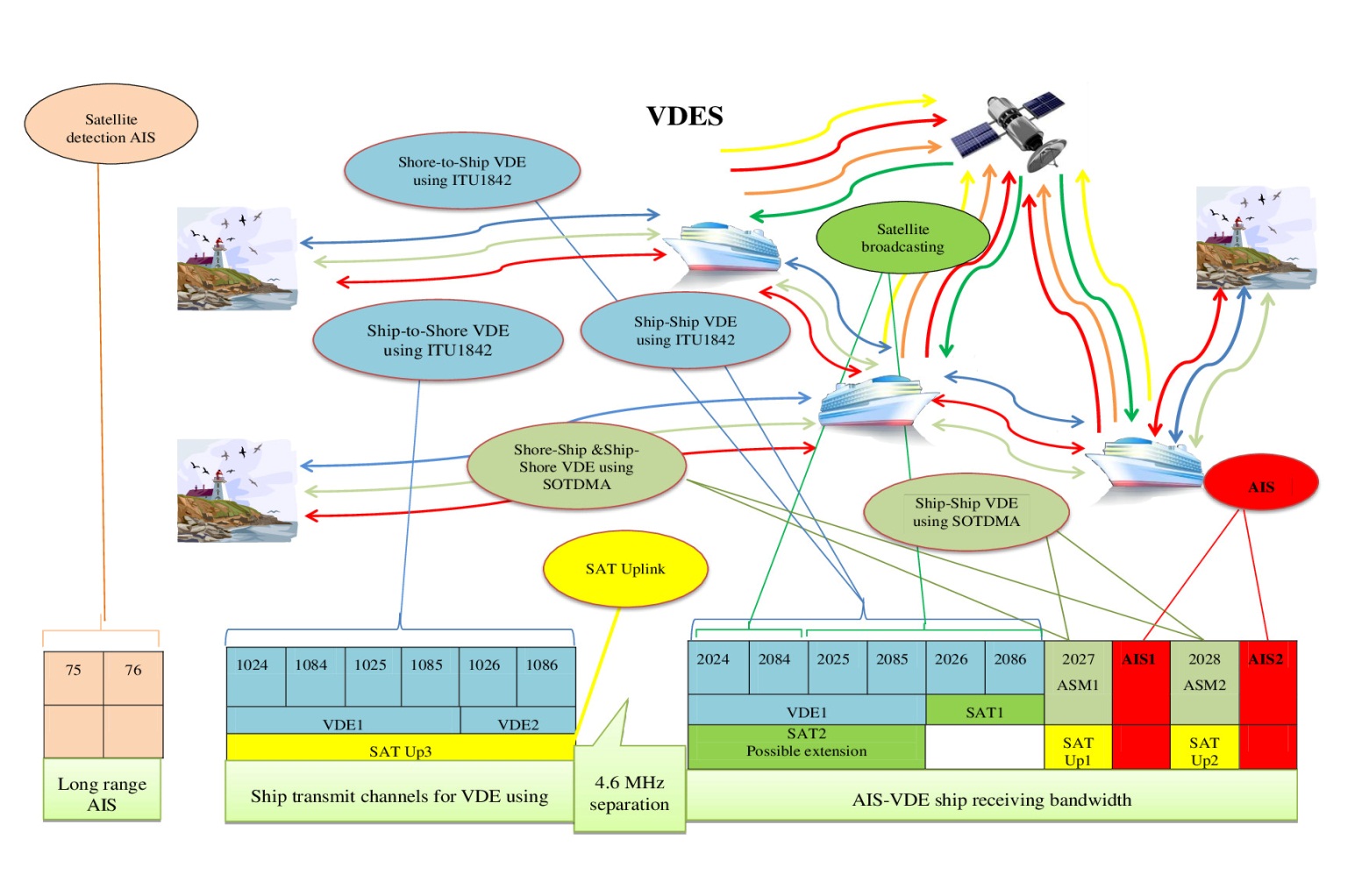
**1.6** The system should be capable of various modes of operation, including the autonomous, assigned and polled modes.

# 2 VDES functions and frequency usage

VDES functions and frequency usage are illustrated pictorally in Figure 1.

**FIGURE 1**

**VDES Functions and Frequency Usage**



Note: SAT Up is receive only by satellite

Table 1 describes the RR Appendix 18 channels used for the various applications of VDES.

**Table 1**

**RR Appendix 18 channels used for VDES applications: AIS, ASM, VDE and SAT**

|  |  |  |
| --- | --- | --- |
| Channel number in RR Appendix 18 | Transmitting frequencies (MHz) for ship and coast stations | |
| Ship stations (ship-to-shore)  (long range AIS)  Ship stations (ship-to-satellite) | Coast stations  Ship stations (ship-to-ship)  Satellite-to-ship |
| AIS 1 | 161.975 | 161.975 |
| AIS 2 | 162.025 | 162.025 |
| 75 (long range AIS) | 156.775 (ships are Tx only) | N/A |
| 76 (long range AIS) | 156.825 (ships are Tx only) | N/A |
| 2027 (ASM 1) | 161.950 (2027) | 161.950 (2027) |
| 2028 (ASM 2) | 162.000 (2028) | 162.000 (2028) |
| 24/84/25/85 (VDE 1)  24  84  25  85 | 25/100 kHz channel  (24/84/25/85, lower legs, merged)  Ship to shore  Ship to satellite | 25/100 kHz channel  (24/84/25/85, upper legs, merged)  Ship to ship, Shore to ship  Satellite to ship under certain conditions |
| 157.200 (1024) | 161.800 (2024) |
| 157.225 (1084) | 161.825 (2084) |
| 157.250 (1025) | 161.850 (2025) |
| 157.275 (1085) | 161.875 (2085) |
| 26/86 (SAT 1/VDE 2)  26  86 | 25/50 kHz channel  (26/86, lower legs, merged)  Ship to satellite/shore | 25/50 kHz channel  (26/86, upper legs, merged)  Satellite/shore to ship |
| 157.300 (1026) | 161.900 (2026) |
| 157.325 (1086) | 161.925 (2086) |

# 3 Identification

Identification and location of all active maritime stations is provided automatically by the AIS. All VDES stations, including satellite stations, should receive AIS messages that identify and locate the source of AIS message transmissions. For the purpose of identification, the appropriate numerical identitfier, for example MMSI, could be used, as defined in the latest version of Recommendation ITU-R M.585. Recommendation ITU-R M.1080 should not be applied with respect to the 10th digit (least significant digit). AIS should only transmit if an MMSI is programmed.

# 4 AIS

AIS is a part of VDES in shipborne stations, shore base stations and satellite stations. AIS should have the highest priority in the VDES, and all other functions should be organized such that the AIS is not adversely affected and its transmission schedule is not delayed.

## 4.1 AIS VHF data link (VDL) non-controlling stations

## 4.1.1 AIS shipborne station

The AIS part of the shipborne VDES should conform to requirements for Class A shipborne mobile equipment using SOTDMA technology as described in Recommendation ITU-R M.1371, except that channel switching should not be used.

## 4.2 AIS VDL controlling stations

### 4.2.1 AIS shore base station

The AIS part of the VDES shore base station should conform to the requirements for AIS base stations as described in Recommendation ITU-R M.1371, except that channel switching should not be used in conjunction with VDES. AIS should have the highest priority of all functions in the VDES shore base station, and all other functions should be organized such that the AIS is not adversely affected and its transmission schedule is not delayed.

**5 Application specific messages (ASM)**

For the VDES, to mitigate AIS VDL loading effects, application specific messages (ASM) should conform to the data structure specified in Recommendation ITU-R M.1371 and may use the two channels designated for ASM in Table 1 (ASM 1 and ASM 2) instead of AIS 1 and AIS 2. Selection of the transmission method should consider the comparison of efficiency and performance of the methods shown in Table 4.

**TABLE 4**

**Comparison of AIS and Potential ASM Data Transfer Methods**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | AIS1 and AIS2  (25 kHz Channels) | Data Transfer Methods  For 25 kHz Channels | | |
| ITU Standard and Digital Modulation | ITU-R M.1371  GMSK | ITU-R M.1842  Annex 1  π/4 DQPSK | ITU-R M.1842  Annex 1  π/8 D8PSK | En 300392-2 v3.2.1 Section 5.11\*  8X 16-QAM |
| Data Rate | 9.6 kbps (1X) | 28.8 kbps (3X) | 43.2 kbps (4X) | 76.8 kbps (8X) |
| Sensitivity | -107dBm | -107dBm | -107dBm | -107dBm |
| Co-channel rejection (CCR) | 10dB | 19dB | 25dB | 19dB |
| Adjacent channel rejection (ACR) | 70dB | TBD | TBD | TBD |
| AIS Message types | 1, 2, 3, 5, 18, 19 … | 6, 7, 8,12,13,14 … | 6, 7, 8,12,13,14 … | 6, 7, 8,12,13,14 … |
| Rationale | Optimum choice for recurring position reports in a ship-ship navigation safety environment. | Provides high (3X) data transmission. Inferior CCR (+9dB) and range discrimination. | Provides high (4X) data transmission. Inferior CCR (+15dB) and range discrimination. | Highest (8X) data rate for a 25kHz channel (compress multi-slot messages to a single slot). |

**6 VHF data exchange (VDE) Terrestrial**

VHF data exchange (VDE) transmissions should use the channels designated for VDE in Table 1. Selection of the transmission method should consider the comparison of efficiency and performance of the methods and channel bandwidths shown in Table 5. The channel access scheme and transmission timing should conform to Recommendation ITU-R M.1842, Annex 5.

**TABLE 5**

**Comparison of Potential Data Transfer Methods for VDE**

|  |  |  |  |
| --- | --- | --- | --- |
|  | VDE Data Transfer Methods For 25 kHz Channels | VDE Data Transfer Methods  For 50 kHz and 100 kHz Channels | |
| ITU Standard and Digital Modulation | ITU-R M.1842 Annex 1  π/4 DQPSK or π/8 D8PSK  or  En 300392-2 v3.2.1 Section 5.11\* (8X 16-QAM) | ITU-R M.1842 Annex 3  16X 16-QAM | ITU-R M.1842 Annex 4  32X 16-QAM |
| Data Rate | 28.8 or 43.2 kbps (3X or 4X)  or  76.8 kbps (8X) | 153.6 kbps (16X) | 307.2 kbps (32X) |
| Sensitivity | -107dBm (ship & shore) | -103dBm (ship stations) | -98dBm (ship stations) |
| Co-channel rejection (CCR) | 19dB or 25dB | 19dB | 19dB |
| Message types | AIS 6, 7, 8,12,13,14 and ASM | VDE messages TBD | VDE messages TBD |
| Rationale | Provides higher (3X or 4X) data transmission than AIS. Inferior CCR (+9dB or +15dB) and range discrimination compared to AIS. | Provides much higher (16X) data transmission than AIS. Inferior CCR (+9dB) and range discrimination compared to AIS. | Provides much higher (32X) data transmission than AIS. Inferior CCR (+9dB) and range discrimination compared to AIS. |

**7 VHF data exchange by satellite (SAT)**

VHF data exchange transmissions by satellite (SAT) should use the channels designated for SAT in Table 1. Selection of the transmission method should consider the comparison of efficiency and performance of the current methods and channel bandwidths. Due to power limitations of satellites and signal power levels required for coordination with terrestrial services, other methods may also be considered as outlined in Annex 2.

Annex 2  
  
Operational and technical characteristics of the VHF data exchange system satellite component

# General

**VHF data exchange system satellite component**

The VHF data exchange satellite component is an effective means to extend the VDES to areas outside of coastal VHF coverage. Hereafter, the satellite component is referred to as the VDE-SAT.

Satellite communications is able to deliver information in a **broadcast**, **multicast** or **unicast** mode to a large number of ships, i.e. efficiently addressing many ships using only minimal radio spectrum resources.

The VDE-SAT will provide a communication channel that is **complementary** to the terrestrial components of the VDES system (i.e. coordinated with terrestrial VHF data exchange (VDE), application specific messages (ASM) and AIS functionalities and their supporting systems).

**Applications**

Continuous exchanges with the maritime community will provide further insight into the priorities, Quality of Service (QoS), security, integrity and other requirements of future VDES services.

There is a large population of smaller size ships - which have no satellite communication equipment on board, but do have regular VHF/AIS reception equipment – that could benefit from the services mentioned above. This would be of particular benefit for vessel populations in areas with limited shore based infrastructure.

Using low-cost satellite reception technology, VDE-SAT can address a large population of ships and offer services for non-SOLAS vessels, fishing vessel, recreational users, life rafts, and even individuals in distress.

# Overall architecture, operational characteristics and assumptions

**Architecture**

The VDE-SAT is composed of one or more satellites transmitting and receiving in the maritime VHF bands – this is the *space segment*.

Due to the frequencies used, it is likely that VDE-SAT will consist of low-earth orbiting (LEO) or medium-earth orbiting (MEO) satellites. VDE-SAT could also consist of hosted payload on spacecraft in such orbits.

Furthermore, the VDE-SAT user terminals will be integrated in ship-borne VDES equipment. This is called the *user segment*. These terminals could be integrated in the terrestrial VDE equipment along with ASM and AIS functionalities. Also VDE-SAT receive-only terminals can be considered: these would provide a very cost-effective means to disseminate maritime information to smaller ships outside terrestrial VHF coverage, for example in areas with limited shore based infrastructure..

Finally, there will be a *ground segment* which consists of one of more ground stations that will send and receive maritime information to/from ships for further processing or dissemination, via the space segment.

**FIGURE 2 VDE-SAT System Archiecture**

**Note: Communication between the coastal VDE station, Maritime information provider and VDE SAT ground station is not part of the VDES architecture**

**Operational characteristics**

The VDE-SAT should complement the VDES terrestrial in areas in which no terrestrial VDE coverage is available, i.e. at the high-seas.

The VDE-SAT should provide a communication channel that is coordinated with terrestrial VDE, ASM and AIS functionalities.

The VDE-SAT should provide a downlink capability (i.e. allow to send information from a ground station to one or more ships). Note that VDE-SAT will likely use its specific unicast, multicast or broadcast capability which is inherent in a satellite downlink.

The VDE-SAT should provide an uplink capability (i.e. allow a ship to send information to the satellite, for further relaying to a ground station).

As VDE-SAT will be based on LEO or MEO satellite(s), provisions will need to be taken for the discontinuous contact that ships will have with individual satellites. Furthermore, if there are multiple VDE-SAT satellites or payload footprints that overlap, some coordination between them may be required.

It is proposed that VDE-SAT supports priority, pre-emption and precedence for different services; this could be mapped into different downlinks.

# Technical characteristics

**VDE-SAT channels and spectrum**

The VDE-SAT downlink should be used for data downlink from the satellite to vessels in a broadcast, multicast or unicast manner. The VDE-SAT should also provide data uplink from vessels to satellites using one or several multiple-access schemes. The data communication exchange via satellite can for example use one of the following methods (as also depicted in the Figure below):



**Figure 3: VDES channel allocation**

**Note: reconcile with Table 1**

1. SAT 1 downlink

The SAT1 downlink frequency spectrum consists of two 25 kHz channels (2026 and 2086). These channels are preferably bundled into one 50 kHz channel to reduce the guard band (needed due to the frequency Doppler shift of incoming signals from LEO satellites), increase the throughput, and more importantly, improve the power efficiency of the satellite power amplifier (avoiding multi-carrier transmission which typically requires a larger output back-off).

The SAT1 signal reception on-board of a ship is likely to be interrupted during the AIS, ASM, DSC, VHF voice and VDE1 (terrestrial) transmission by the same ship. The frame structure for SAT1 downlink should facilitate the signal reacquisition and minimize the loss of VDE-SAT downlink frames. This may be accomplished by coordinated time allocation or other means to mitigate interference.

Due to the power flux limit imposed on the VDE-SAT downlink (as part of frequency sharing criterion with land mobile), a certain level of redundancy (in the form of frame repetition, forward error correction or higher layer redundancy) should be implemented in the VDE-SAT protocol in order to mitigate the error and enhance the data detection probability.

The VDE-SAT downlink signal should also include repeated known symbols (pilots, preamble, post-amble) to facilitate signal detection and synchronization as well as possible interference mitigation and channel estimation.

In order to avoid unwanted in-band spectral lines, the data symbols should be scrambled with a known sequence.

1. VDE-SAT Extended Downlink (SAT1 + SAT 2 downlink extension)

At high seas, in the absence of shore-to-ship and ship-to-ship data exchange, the satellite data downlink can be significantly improved by assigning the entire 150 kHz bandwidth (corresponding to the upper frequency allocation of the VDES) to the satellite downlink. This will allow for considerably larger volume of data downlink to ships per each satellite pass in high seas.

The signal level generated by the satellite at the SAT2 frequency range will be kept below the power flux density level limit (i.e. -125 dBW/m2 per 4 kHz) so that there is no harmful interference caused by the satellite downlink on the terrestrial VDE signal sharing the same frequency (ensuring in-band Carrier-to-interference requirements of terrestrial VDE receivers).

It is envisaged that ship-borne receivers with a higher computation capabilities can detect terrestrial VDE and satellite downlink VDE that share the same frequency band.

Within the VDES system further dissemination of data can be achieved through mesh networking mechanisms where the data received from the satellite is relayed to other users using the terrestrial ship to ship VDE.

1. SAT 3 Uplink

At the high sea, the frequency spectrum corresponding to 6 lower VDE channels (starting from Channel 1024) will be used for satellite data uplink. Compared to the AIS channels, and long range AIS, these 6 channels with a contiguous bandwidth of 150 kHz provide a significant data uplink capability via satellite.

The access scheme protocol for data uplink via satellite will be carefully designed to take into account multiple self-organized networks within the satellite field of view and to maximize the probability of message detections by avoiding message collisions or devising methods to resolve the collisions.

To avoid any coordination with terrestrial services, the satellite data uplink will only be used out of VDES coastal coverage.

Similar to satellite based reception of AIS1 and AIS2 channels, the ship-borne data on channels 2027 and 2028 can be detected by satellite purely in a reception mode (without satellite component making any intervention in SOTDMA network organization). A detection performance similar or improved compared to the current SAT-AIS is expected.

**Rationale of channel allocation for VDE-SAT**

The frequency plan for the entire VDES, as depicted in Figure 3 above, facilitates a realistic implementation of the proposed system in co-existence with and complementing the current AIS. The following points regarding the proposed frequency plan should be highlighted:

1. The requirements for VDES (together with the existing AIS) concentrate the reception frequencies on board of the ship to a limited range of 250 kHz at the upper maritime VHF band. This will allow an efficient implementation of VDES/AIS on-board receivers by narrowing the input filter bandwidth, reducing potential impairments due to other activities within the maritime VHF band.
2. The VDE-SAT downlink will be hosted within the same frequency range as the terrestrial VDE and AIS. This allows sharing the same antenna as well as the receiver front-end design.
3. Satellite and shore reception frequencies of ship-born VDE signals occupy the lower end of the VHF maritime band. This will allow for a complementary service close to the shore and at the high sea while sharing the same spectrum. The frequency separation between the upper and lower spectra (with 4.45 MHz separation) will allow acceptable level of isolation between VDES/AIS receiving chain and the VDE ship-borne transmitters.
4. The frequency separation between SAT1/SAT2 and SAT3 will allow hosting VDE-SAT transmitter and receiver on the same satellite which allows for a more cost-effective satellite mission concepts (i.e. reduce number of satellites, improved efficiency and possible interactivity).

Annex 3  
  
Abbreviations in use in this Recommendation

AIS Automatic identification system

1. \* This Recommendation should be brought to the attention of the International Maritime Organization (IMO), the International Civil Aviation Organization (ICAO), the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA), the International Electrotechnical Commission (IEC) and the Comité International Radio Maritime (CIRM). [↑](#footnote-ref-1)